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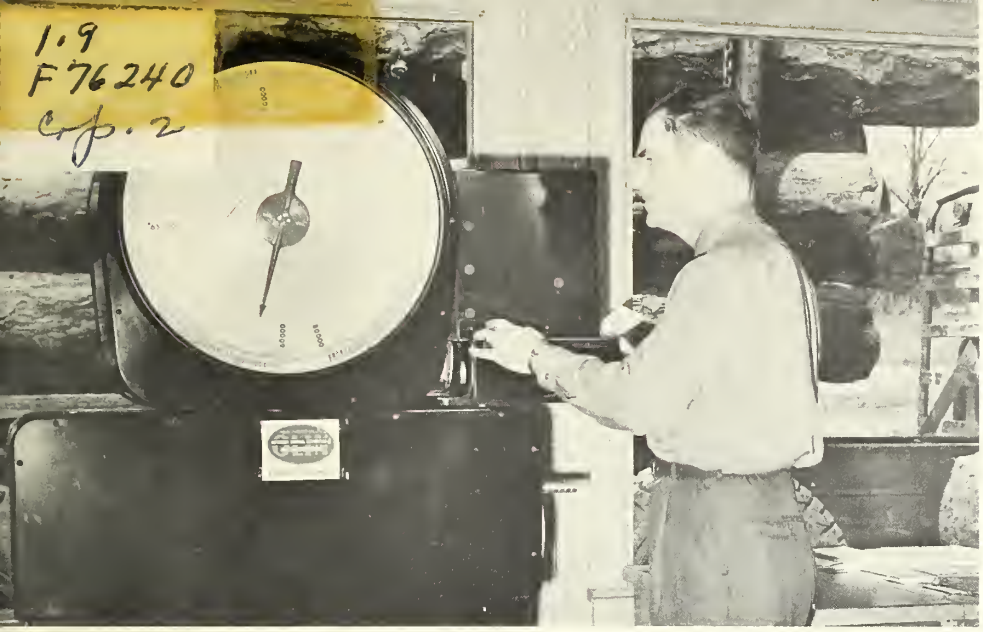

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WEIGHT-SCALING

SOUTHERN PINE

SAW LOGS

Sam Guttenberg

Donald Fassnacht, William C. Siegel

SOUTHERN FOREST
EXPERIMENT STATION
Philip A. Briegleb, Director

●

FOREST SERVICE

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U. S. DEPARTMENT
OF AGRICULTURE

Acknowledgment

The Woodlands Department of the Olin Mathieson Chemical Corporation made this research possible by providing timber, log-handling and milling facilities, manpower, and photography.

LOG SCALE TICKET
CONTRACTOR
DATE
SCALER
TIME
CONTRACT NUMBER
NO. OF LOGS
Lbs. Gross
Lbs. Tare
Lbs. Net
Gross scale
Deductions
Net scale

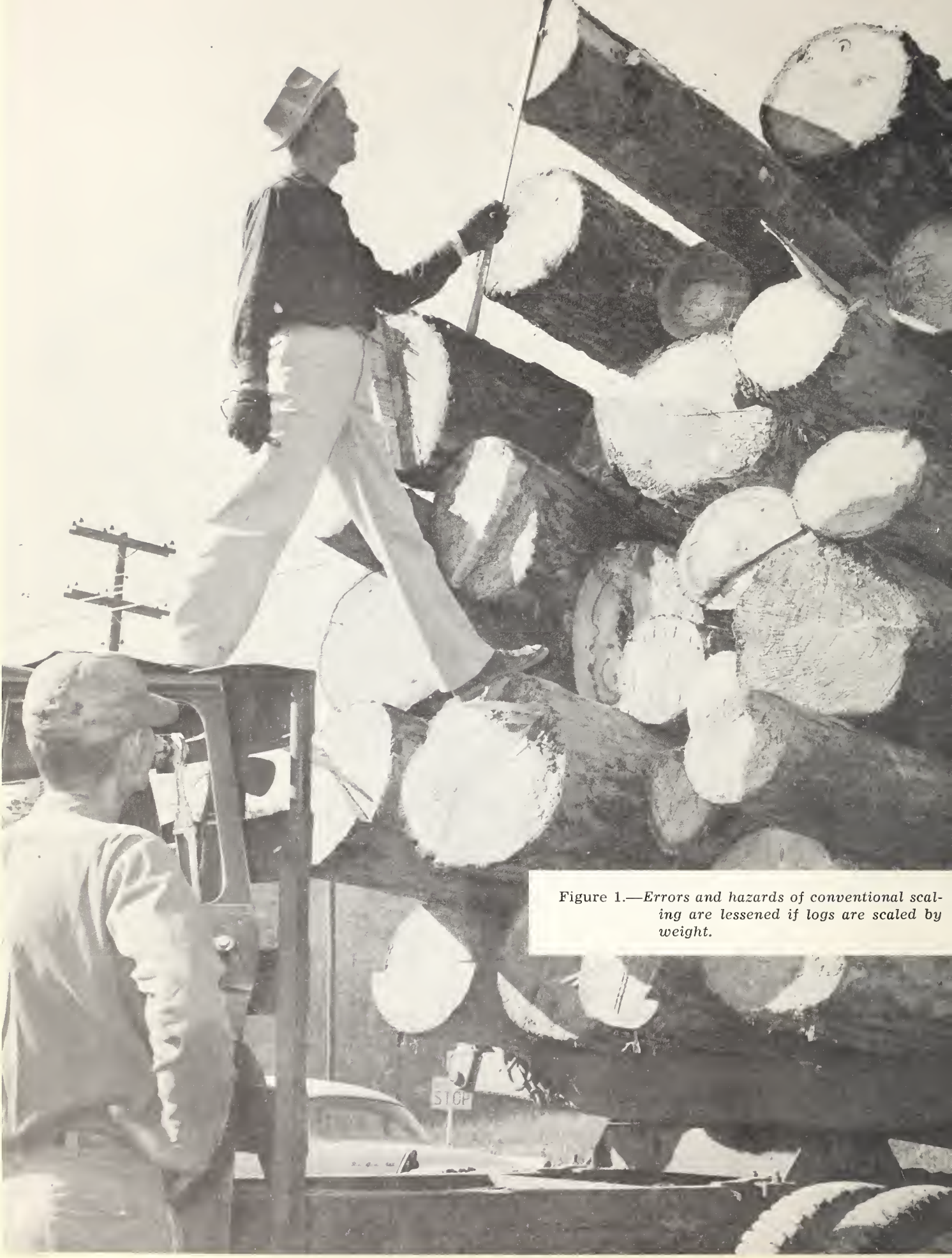

Figure 1.—*Errors and hazards of conventional scaling are lessened if logs are scaled by weight.*

WEIGHT-SCALING

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SCALING BY WEIGHT promises equal accuracy and greater day-to-day consistency in predicting lumber yields from southern pine saw logs than scaling by traditional log-rule methods. In a study with loblolly and shortleaf pine saw logs, the log-to-lumber prediction was closer when based on the weight of the logs than when derived from values of the Doyle, Scribner Decimal C, or International rules. When weighing is done by truckloads rather than by individual logs, relative accuracy can be further enhanced, and substantial savings in time and money can be realized.

The precision of the weight-yield relationships developed for the mill under study suggests the suitability of weight-scaling in the southern pine region. While individual mills will have to develop factors for their local conditions, several potential advantages of weight-scaling seem to assure its future:

A single objective measurement that can supplant scaling by timber growers, loggers, haulers, and mill men.

The elimination of stick scaling's log-by-log computations and opportunities for error.

Shorter truck turnaround time at the mill.

Feasibility of uncontested spot payment for delivered logs.

A stimulus for delivery of green logs, free from stain.

Lessening of the risk of physical injury to scalers.

FIELD METHODS

A total of 203 pine saw logs were chosen from the forests of southern Arkansas and northern Louisiana (fig. 2). The object was to obtain representation of each diameter class from 6 to 20 inches (table 1). Lengths varied from 12 to 20 feet, and both shortleaf and loblolly were represented. None had rot or sweep enough to require downgrading by the *Interim Pine Log Grades* (9).[1] The exclusion of defective logs appeared justified by the Forest Survey's findings that only 3 percent of the area's gross pine volume is defective.

The following factors were measured at the mill yard, before the logs were more than 5 days from the stump:

Diameter—Minimum and maximum diameters were taken at the small end of each log, to the nearest 0.01 foot, inside bark.

Length—The longest and shortest log faces were taped to the nearest 0.01 foot.

Figure 2.—*Log sources.*

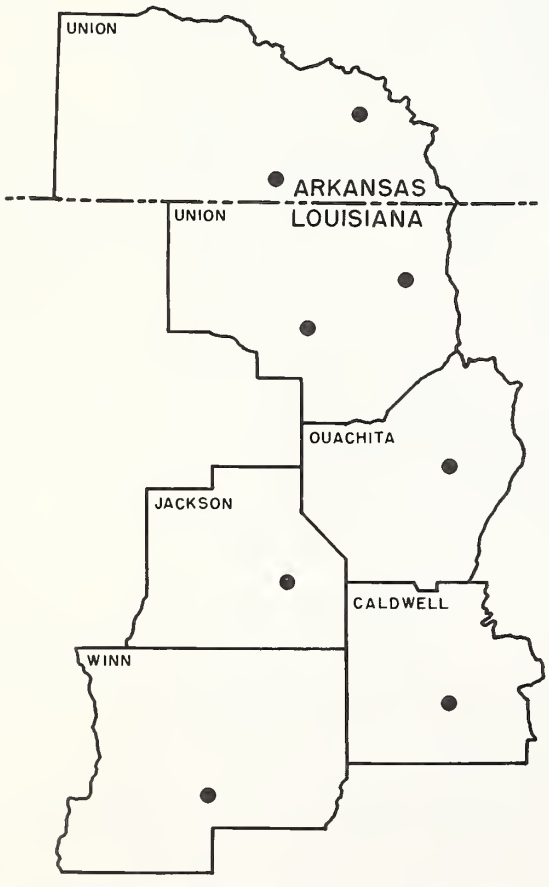

Table 1.—*The log sample*

Diameter class, i. b. (inches)	Length[1] 12 feet	14 feet	16 feet	18 feet	20 feet	All logs	Butt logs
	Number of logs						
6	5	...	7	1	...	13	2
8	10	9	8	2	...	29	7
10	3	8	15	1	4	31	4
12	2	5	12	4	7	30	8
14	1	10	7	9	3	30	6
16	...	3	13	7	7	30	16
18	1	5	3	4	7	20	10
20+	1	1	8	6	4	20	12
Totals	23	41	73	34	32	203	65

Weight—Each log was weighed twice, to the nearest 10 pounds. At every tenth log the scales were calibrated with 1,000 pounds of standard 50-pound check weights.

Lumber yield—Each log was sawn to 4/4 boards, except that an 8/4 center piece was used to control log identity through the mill. Each board was scaled and graded in terms of finished lumber.

Moisture percent—A wafer was taken one foot from each end of the 8/4 center piece and green weight determined immediately.

Specific gravity—Additional wafers were cut adjacent to the moisture content samples. The ratio of green volume to oven-dry weight was determined in a laboratory.

All factors measured twice were averaged and the mean values used in the analyses.

SINGLE-LOG ESTIMATES

From weights and lumber yields of the individual logs, a factor was developed for predicting lumber tally from logs of various weights. A condensed set of values, based on this factor, is found in Table 2.

Table 2.—*Lumber yield from southern pine logs of various weights*

Log weight (pounds)	Predicted green lumber yield[1]
	Board feet
200	9
600	51
1,000	94
1,400	138
1,800	184
2,000	207
2,200	231
2,600	278
3,000	328

[1] $\text{Board feet} = \frac{\text{Weight}}{9.88} + \frac{(\text{Weight})^2}{254{,}362} - 10.96$

[1] Bold-face numbers in parentheses refer to Literature Cited, p. 6.

How did weight-scaling with this factor compare with standard log-rule scaling? Figure 3 provides a visual comparison. Charts for weight and for three log rules are drawn to the same proportions. The diagonals represent exact agreement between estimated and actual lumber yields. The dots represent the 203 study logs. If all dots fell on the diagonals, the prediction would be perfect.

The patterns in Figure 3 indicate that a weight factor can compare favorably with precise log-rule scaling. Since sawing is rarely done to standard log-rule specifications and the weight estimator is based on actual yield of the 203 logs, this was not unexpected.

The popular Doyle rule behaves normally. Lumber yield is substantially underestimated: very few points appear to the right of the diagonal. The arched dot pattern illustrates the variation in overrun with log size. The dots in the Scribner chart cluster around the diagonal but not so closely as those in the weight diagram. International-rule predictions fall chiefly below the diagonal—signifying underrun. This rule requires production of 4- and 6-foot boards, but the mill preferred to manufacture pulp chips instead of shorts.

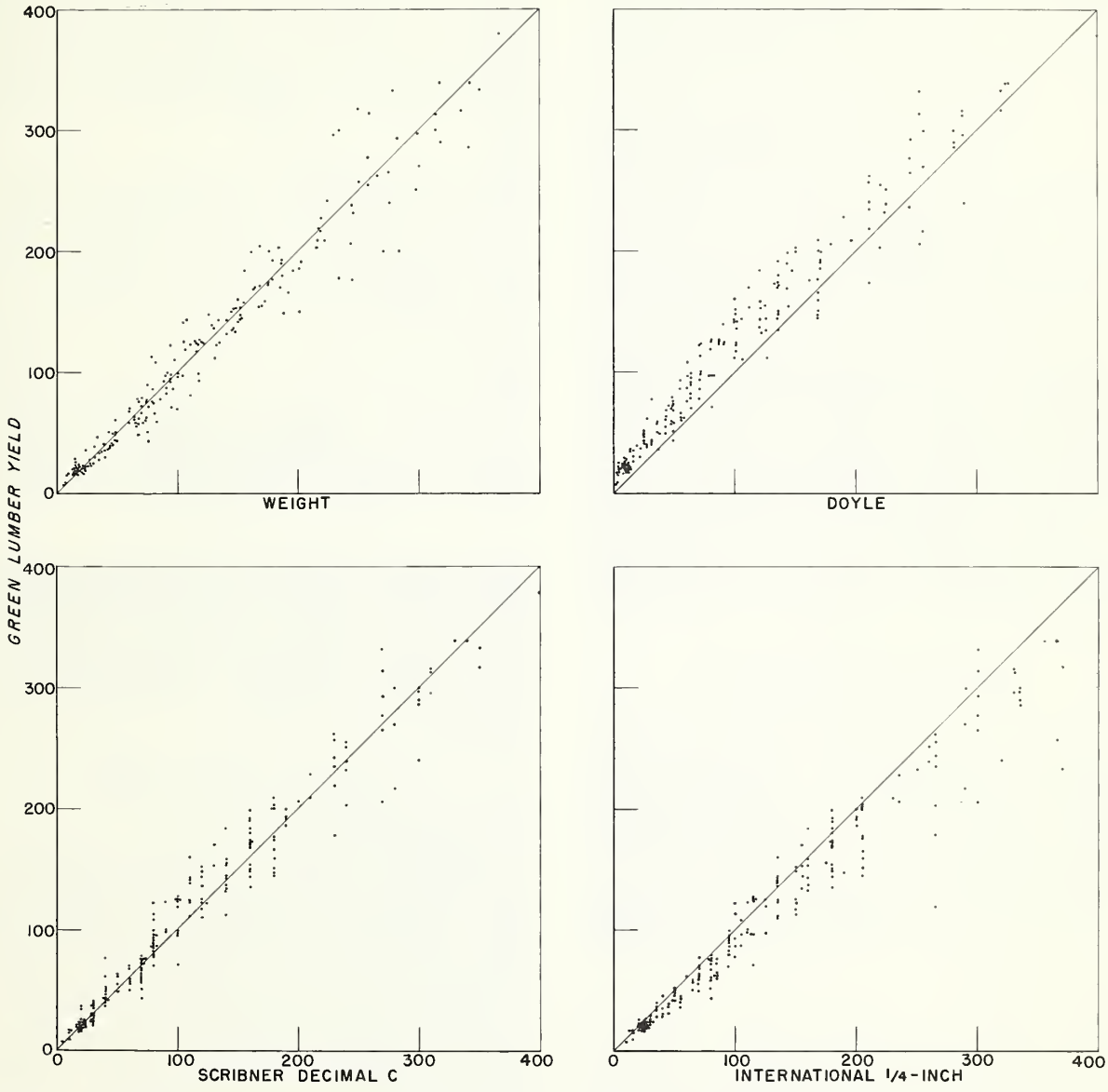

Figure 3.—*Comparison of weight-scaling with standard log-rule scaling. All values are in board feet.*

The charts indicate that weight is a good predictor of lumber outturn. A statistical analysis summarized on page 6, was designed to answer the question, "Can weight alone account for the single or combined effects of such variables as diameter, length, moisture content, or specific gravity in predicting lumber yield?"

The analysis indicated that for practical purposes weight alone will do the job. Adding the effects of moisture content and specific gravity improved the prediction made from weight alone, but the gain was very small and does not justify the cost of taking the measurements.

Differences in the moisture content of trees from season to season have sometimes been thought to complicate weight-scaling. While the present test offered no evidence on this point, the U. S. Forest Products Laboratory (7) has found no significant seasonal moisture differences. Recently, Dr. R. M. Echols of the Southern Institute of Forest Genetics sampled living southern pines throughout the year. Though he found sizable differences in moisture content between trees, the seasonal moisture differences within any one tree were negligible.

Because of its susceptibility to rapid changes in moisture content, outer bark may also seem an important source of weight variation. King and Taras, however, report that usually 10 percent or less of saw-log weight is bark (4, 10). When local weight factors are developed, sampling loads or logs over a period of several months substantially accounts for the variation in bark moisture.

TRUCKLOAD ESTIMATES

As most industrial weight-scaling will be done in truckload lots, a weight factor was computed for this purpose. Yearlong scaling records indicated that the typical single-axle logging trucks were carrying loads of 20 to 35 logs. Simulated loads ranging from 20 to 33 logs were therefore drawn randomly from the data. Weights of the loads varied from 22,000 to 43,100 pounds and volumes from 2,089 to 4,361 board feet.

The calculated truckload weight factor is shown as the solid line in Figure 4. It represents the average relationship between lumber yield and load weight. The clustering of dots about the line suggests the reliability of estimating truckloads by weight. Minor differences between the dots and the line were not related to variations in log counts between loads. According to the chart, 10,300 pounds of logs will average 1 MBF of green lumber.

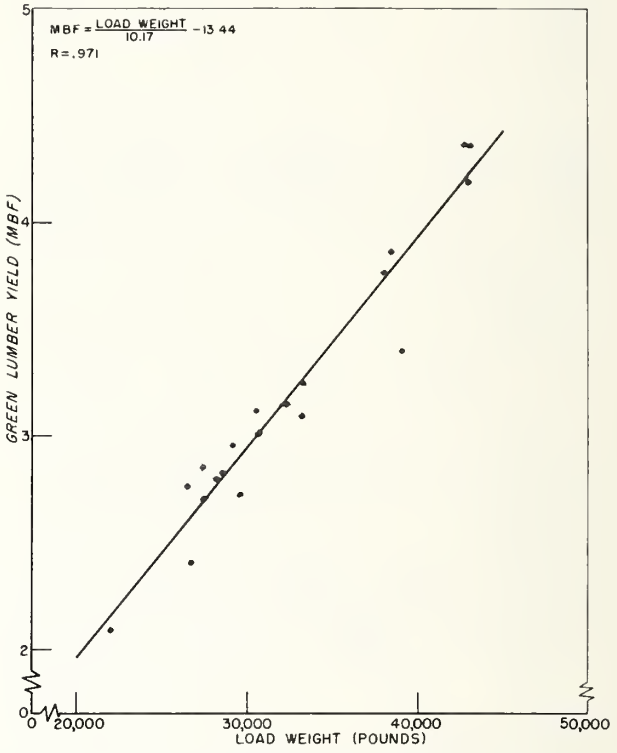

Figure 4.—*Truckload weights can be an accurate index to lumber yields.*

By the International rule, 9,338 pounds of logs equaled 1 MBF. This value conforms closely with the 9,234 pounds from Schumacher's study in Virginia (8). Schumacher also found weight estimation unaffected by the number of logs per load.

INDUSTRIAL APPLICATION

Converting to Weight-Scaling

A company wishing to adopt weight-scaling must develop its own factors to account for local variations in species, site, log size, and milling practice. Most mills will achieve greater yields per ton of logs than were secured in this study, because they will cut more dimension and timbers. For southern pine, average factors will fall between 7 and 12 pounds of logs per board foot of green lumber.

Valid local factors for truckload lots can be developed in a variety of ways. The single-log approach used in this study takes fewer logs than do truckload appraisals, but requires year-long scale records from which to reconstruct representative loads.

A rough-and-ready factor can be had by selecting about 50 loads at random over a period of months and dividing the gross yield (either in company scale or green-chain tally) by the gross weight. If records are kept by individual loads, mathematical analysis of the data becomes possible. Among other things, such analysis can determine the reliability of the factor at different load weights, the number of loads that must be sampled to achieve specified accuracy standards, and the variation in log or load characteristics that might affect the factor.

After the yield factor has been determined, occasional checks will be desirable. Log trim allowance should also be measured periodically. Mills whose average log size tends to be fairly stable can utilize a single weight per MBF.

When individual sources of supply show considerable variation in log size, value factors can be adjusted to the number of logs per ton—in the same fashion that log diameter is used.

Under today's conditions, firms sawing more than 5 million board feet annually can benefit from measuring logs by weight. Equipment, installation, and housing will cost from $8,000 to $12,000. This assumes a 34- by 10-foot drive-on model with 30-ton capacity—a suitable size for most mills. It would have a direct-reading dial and unit for printing gross, tare, and net weight on cards. Depending upon the mill's annual cut, savings over conventional scaling and bookkeeping alone should recover costs in 2 to 5 years. Mills that receive considerable timber in logs longer than 20 feet will probably need scales of 50 to 60 tons' capacity.

Firms converting to weight estimation will find an educational program helpful in speeding acceptance. Initial reaction of loggers, haulers, and timber growers to weight-trading is likely to reflect human resistance to change. The Wells-Griffin Lumber Company of Georgia (1) has made a successful conversion to weight. To retain good will it began by offering to scale as well as weigh loads for any contractor who desired a comparison.

The overrun from the Doyle rule is still a favored control device of mill managers, though shifts in average log size between accounting periods affect the percent of overrun. In conversion to weight-scaling, the advantages of the device can be retained by adjusting locally derived mill-tally weight factors for whatever overrun percent is desired.

Present and Future Uses

By recording the weight of loads assigned to storage, truckload weight factors can be used for inventory control. When inventory of depleted piles is required, weighing offers considerable savings over scaling. Moisture changes during fall and winter storage can be ignored. Cuno and Lindgren (2, 5, 6) found that during 2 to 3 months of fall or winter storage, moisture loss in southern pine pulpwood bolts was negligible. They also established that loss declined as bolt diameter increased. Thus, saw logs would lose even less moisture in storage. Within the plant, logs can be sorted by weight into broad diameter classes to feed different sides of a mill or gangsaws. Material more suitable for chipping than sawing also could probably be classified by weight.

Both research and management are increasingly aware of the advantages of describing timber stands and yields in tons per acre. Weight-scaling will facilitate the trend toward managing timber by the ton. For this reason, as well as for the more immediate benefits already noted, it is likely to become common practice in the South.

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APPENDIX

The Southern Forest Experiment Station's 704 regression program (3) was used to obtain the solutions to all 255 possible equations involving the 8 variables in the single-log analysis:

X_1 = Weight
X_2 = $(X_1)^2$
X_3 = Length
X_4 = (X_2) (X_3)
X_5 = (X_1) (X_3)
X_6 = Specific gravity
X_7 = (X_6) (moisture percent)
X_8 = Scaling diameter

As Table 3 indicates, the biggest relative gain in precision was achieved by adding log moisture percent and specific gravity to weight. Though additive effects were had from various functions and combinations of log weight, length, and diameter, their practical significance was nil.

Table 3.—*Regressions with highest R^2 for each level*

Variables	R^2	S. E.
		Board feet
X_1, X_2, X_4, X_5, X_6, X_7, X_8	0.970	15.47
X_1, X_2, X_4, X_5, X_6, X_8	.970	15.63
X_2, X_5, X_6, X_7, X_8	.969	15.70
X_2, X_3, X_6, X_8	.967	16.18
X_1, X_6, X_7	.966	16.35
X_1, X_7	.964	16.91
X_1	.956	18.60

Because the yield from heavy logs varied more widely than that from lighter ones, a final regression was fitted to the data on the assumption that the variance was proportional to log weight. The equation is:

$$Y = \frac{\text{Weight}}{9.88} + \frac{(\text{Weight})^2}{254{,}362} - 10.96$$

$R^2 = .980$